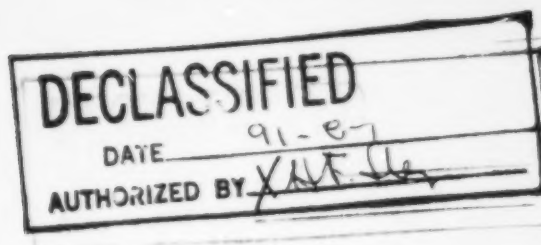


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**MINERALOGICAL EXAMINATION OF GOLD-BEARING
SAMPLES FROM THE DAVID BELL CIRCUIT,
FOR TECK-CORONA OPERATING CORPORATION**

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MINERALOGICAL EXAMINATION OF GOLD-BEARING SAMPLES
FROM THE DAVID BELL CIRCUIT FOR TECK-CORONA OPERATING CORPORATION

by

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ABSTRACT

Two samples, one from leach tank #8 and another of CIP tails, from the David Bell circuit of Teck-Corona Operating Corporation were studied to determine the gold liberation size and mineral associations with the gold-bearing grains. The samples contain, 0.0484 oz/tonne (1.66 g/t) Au and 0.0458 oz/tonne (1.57 g/t) Au respectively. Sieved fractions were subjected to heavy liquid separations, and the sink products were examined by ore microscopy, and scanning electron microscopy to identify the minerals and to determine mineral associations. Selected grains were analyzed with the electron microprobe to determine mineral compositions. It was found that the Au minerals are aurostibite and Au-Hg-Ag and Au-Ag alloys. The aurostibite was not dissolved because it is insoluble in cyanide solutions, and most of the Au-Ag-Hg and Au-Ag alloys were not dissolved because they occur as minute grains encapsulated in silicates, pyrite and titanite. Some of the gold alloy is present as large liberated grains which suggests either incomplete dissolution or coatings of As and/or Sb on the grains. The encapsulated grains of Au-Hg-Ag and Au-Ag alloys are smaller than 12 μm in diameter, hence a regrind of about 80 μm minus 10 μm would be required to liberate them. A somewhat coarser regrind might, however, fracture many of the host particles and expose the encapsulated grains. It is likely that a regrind would create new surfaces on the large liberated gold alloy grains.

Keywords: gold-mercury-silver alloy, aurostibite, gold losses, CIP tails

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**EXAMEN MINÉRALOGIQUE D'ÉCHANTILLONS CONTENANT DE L'OR
DU CIRCUIT DAVID BELL POUR LA TECK-CORONA OPERATING CORPORATION**

par

J.H.G. Laflamme* et W. Petruk**

RÉSUMÉ

Deux échantillons, l'un de la cuve de lixiviation #8 et l'autre de l'absorption par le charbon actif, du circuit David Bell de la Tech-Corona Operating Corporation ont été étudiés pour déterminer la granulométrie de l'or libéré et les associations minérales des grains contenant de l'or. La teneur en Au des échantillons était de 0,0484 oz/tonne (1,66 g/t) et 0,0458 oz/tonne (1,57 g/t), respectivement. Les fractions tamisées ont été soumises à des séparations dans des liquides lourds et les produits déposés ont été examinés au microscope pour minerai et au microscope à balayage électronique pour connaître les minéraux et leurs associations. Certains grains ont été analysés à la microsonde électronique pour déterminer la composition du minéral. On a constaté que les minéraux aurifères étaient l'aurostibite et des alliages Au-Hg-Ag et Au-Ag. L'aurostibite ne se dissolvait pas, car elle est insoluble dans les solutions de cyanure, et la plupart des alliages Au-Ag-Hg et Au-Ag ne se dissolvaient pas par ce que les petits grains étaient encapsulés dans des silicates, de la pyrite et de la titanite. Une partie des alliages est sous forme de gros grains libres, ce qui semblerait indiquer que la dissolution est incomplète ou qu'il y a des revêtements de As et/ou Sb sur les grains. Les grains d'alliages encapsulés ont moins de 12 μm de diamètre, ce qui fait qu'un autre broyage qui donnerait environ 80 % de particules de moins de 10 μm les libérerait. Un broyage un peu moins fin pourrait toutefois fracturer beaucoup des particules et exposer les grains encapsulés. Il est probable qu'un rebroyage créerait de nouvelles surfaces sur les gros grains d'alliages d'or libérés.

Mots-clés : Alliages or-argent-mercure, aurostibite, pertes d'or absorbées par le charbon actif

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INTRODUCTION

Two samples of CIP tails from the David Bell circuit of Teck-Corona Operating Corporation were studied at CANMET (Pinard and Petruk, April, 1991) to determine the gold liberation size and mineral associations of locked gold grains. The samples contained 0.0312 oz/tonne (1.07 g/t) Au and 0.0159 oz/tonne (0.55 g/t) Au, respectively. Only one large liberated grain of gold was found in the sample with the higher gold content, hence the study did not determine the source of gold. A further study, using a different approach, was recommended. On May 3, 1991 Muriel Goodfellow, metallurgist, Teck-Corona Operating Corporation, David Bell Mine, P.O. Bag 11, Marathon, Ontario, POT 2EO submitted two more samples. Ms. Goodfellow stated that one sample was from leach tank #8 (sample No. 1) and the other is CIP tails (sample No. 2). She reported that sample No. 1 contains 0.0484 oz/tonne (1.66 g/t) Au, and sample No. 2 contains 0.0458 oz/tonne (1.57 g/t) Au. A purchase order (purchase order DC00914270) for \$2,000.00 was enclosed to cover the cost of the study. The project was filed as MSL Project No. 474, Cost Recovery Job No. 50278.

SAMPLES AND METHOD OF INVESTIGATION

The samples were mixed thoroughly and each was split into two roughly equal portions. One portion (320 and 367 g for samples No. 1 and No. 2, respectively) was sieved (Table 1) into +106 μm (+150 mesh), 106 to 44 μm (150 to 325 mesh) and -44 μm (-325 mesh) fractions. The +106 μm and 106 to 44 μm fractions were separated into sink and float sub-fractions using methylene iodide (S.G. = 3.3). The other portion of each sample, the -44 μm fractions, and the 106 to 44 μm float sub-fractions were submitted to the Chemical laboratory for Au assay (Table 2).

Table 1. Sieve Analysis and Heavy Liquid Separations

Fraction (μm)	Sample No. 1 wt.%	Sample No. 2 wt.%
+106	8.0	10.1
106 to 44	33.4	33.1
-44	58.6	56.8
Total	100.0	100.0
106 to 44 float	99.6	99.25
106 to 44 sink	0.4	0.75
Total	100.0	100.00

Table 2. Assay Results of the Samples

Sample No	Whole sample		-44 μ m**	+44 μ m***	106 to 44 μ m fl**
	Au g/t	Au g/t	Au g/t	Au g/t	Au g/t
	Teck*	CANMET**			
1	1.66	1.92	1.97	1.85	1.63
2	1.57	1.61	1.71	1.48	1.70

* assays by Teck-Corona;

** assays performed at CANMET;

*** calculated.

The sink products were mounted as monolayer polished mounts which were carefully prepared to avoid plucking of micron-sized gold-bearing grains. A detailed mineralogical investigation was performed by reflected light microscopy using a 16x objective and a mechanical X-Y stage to ensure that the entire polished surface was examined. Grains of interest were marked and further studied with a scanning electron microscope (SEM) equipped with an energy dispersion spectrometer (EDS) for mineral identification. Additional quantitative analyses were done on a few grains of Au minerals by wavelength dispersion spectrometry (WDS) using an electron microprobe. Some of the silicates were identified by X-ray diffraction (XRD) analysis.

RESULTS

The major constituents in the samples, identified by XRD, are quartz, muscovite, plagioclase and chlorite.

The major opaque minerals identified in the sink products are pyrite (FeS_2) and molybdenite (MoS_2), minor opaque minerals are stibnite (Sb_2S_3), sphalerite (ZnS), arsenopyrite (FeAsS), chalcopyrite (CuFeS_2), and pyrrhotite (Fe_{1-x}S), and trace minerals are gudmundite (FeSbS), ullmannite (NiSbS), chalcostibite (CuSbS_2), berthierite (FeSb_2S_4), Sb metal (Sb), gersdorffite (NiAsS), galena (PbS), and cinnabar (HgS). Gold minerals identified are Au-Ag and Au-Hg-Ag alloys, and aurostibite (AuSb_2). The findings on the Au minerals are discussed individually for each sample.

Sample No. 1

The Au minerals observed in sample No. 1 are aurostibite and Au-Hg-Ag alloys (Table 3A). Seven grains of aurostibite, which range from 7 x 10 μ m to 40 x 70 μ m, were found in the sink products, either as totally liberated grains (Fig. 1) or associated with other minerals such as stibnite and berthierite (Fig. 2), quartz (Figs. 3 & 4), native Sb (Fig. 4) or Na-Ca-Al silicates (Fig. 5).

About fifteen small grains of a Au-Hg-Ag alloy, ranging in size from $<2\ \mu\text{m}$ to $8 \times 8\ \mu\text{m}$ were also observed in the sink products of sample No. 1. One grain was encapsulated in pyrite (Fig. 6), whereas the other grains were encapsulated in Ca-Al or Na-Ca-Al silicates (Fig. 5).

Table 3A. Gold Grains Observed in Sink Products (Sample No. 1)

Mineral	Size (μm)	Association
Aurostibite	30 x 35	minor stibnite, berthierite (Anal. 1, Fig. 2)
"	30 x 32	minor quartz (Anal. 2, Fig. 3)
"	40 x 70	totally liberated (Anal. 3, Fig. 1)
"	18 x 40	stibnite
"	15 x 28	native Sb in quartz (Fig. 4)
"	7 x 10	within Na-Ca-Al silicate (Fig. 5)
"	10 x 15	within Na-Ca-Al silicate (Fig. 5)
Au-Hg-Ag alloy	8 x 8	within pyrite (Anal. 7, Fig. 6)
"	2 x 3	within Ca-Al silicate
"	3 x 12	within Na-Ca-Al silicates (Anal. 9, Fig. 5)
"	5 x 5	within Na-Ca-Al silicates (Anal. 9, Fig. 5)
"	4 x 6	within Na-Ca-Al silicates (Anal. 9, Fig. 5)
"	3 x 6	within Na-Ca-Al silicates (Anal. 9, Fig. 5)
"	2 x 10	within Na-Ca-Al silicates (Anal. 9, Fig. 5)
"	(8) <2	within Na-Ca-Al silicates (Anal. 9, Fig. 5)

Table 3B. Gold Grains Observed in Sink Products (Sample No. 2)

Mineral	Size (μm)	Association
Au-Hg-Ag alloy	5 x 12	within pyrite (Anal. 8, Fig. 8)
Au-Ag alloy	35 x 65	totally liberated (Anal. 4, Fig. 7)
Au-Hg-Ag alloy	5 x 10	within titanite (Anal. 5, Fig. 9)
"	2.5 x 2.5	within quartz (Fig. 10)
"	1 x 2	within quartz (Fig. 10)
"	1 x 1	within quartz (Fig. 10)
Au-Ag alloy	8 x 65	totally liberated

Sample No. 2

Au-Ag and Au-Hg-Ag alloys are the only Au minerals found in sample No. 2. Seven grains ranging in size between $<2\ \mu\text{m}$ to $35 \times 65\ \mu\text{m}$ were observed, two totally liberated (Fig. 7) and the rest encapsulated in either pyrite (Fig. 8), titanite (Fig. 9), or quartz (Fig. 10).

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Microprobe analyses on selected grains of the Au minerals from sample Nos. 1 and 2 are given in Table 4.

Table 4. Electron microprobe analyses of Au-bearing minerals

Anal. no.	Weight per cent					Total
	Au	Ag	Hg	Sb	As	
Aurostibite (AuSb ₂)						
1.	45.8	-	-	52.5	0.11	98.41
2.	46.3	-	-	52.7	0.07	99.07
3.	47.2	-	-	51.6	0.16	98.96
Au-Ag/Au-Hg-Ag alloys						
4.	95.8	2.8	-	-	-	98.6
5.	71.8	3.9	21.2	-	-	96.9
6.	98.2	1.7	0.1	-	-	100.0
7.	87.6	5.1	5.6	-	-	98.3
8.	91.4	0.65	6.0	-	-	98.05
9.	88.3	0.29	9.8	-	-	98.39

DISCUSSION

The gold minerals found in the leach tank sample are aurostibite and minute grains of Au-Hg-Ag alloys encapsulated in silicates and pyrite. The Au-bearing minerals found in the CIP tails are minute grains of Au-Hg-Ag and Au-Ag alloys encapsulated in silicates, pyrite and titanite, and large liberated grains of Au-Hg-Ag and Au-Ag alloys. The aurostibite has remained in the tails because it is insoluble in cyanide solutions (Harris, 1989), and the encapsulated Au-Hg-Ag and Au-Ag alloys were not recovered from the ore because they were not exposed to cyanide solutions (Cabri, 1988, Petruk, 1989). It is likely that the liberated grains of Au-Hg-Ag and Au-Ag alloys were not dissolved in the cyanide solution because they have become coated with a monolayer of an element, such as As or Sb, which protects the gold from the cyanide-bearing solution (Cabri, 1988, Petruk, 1989). The As and Sb are derived from the As- and Sb-bearing minerals in the ore. It is also possible that there was incomplete dissolution of gold because the gold grains were initially very large and there was insufficient time for dissolution.

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The encapsulated grains of Au-Hg-Ag and Au-Ag alloys and the liberated grains of Au-Hg-Ag and Au-Ag alloys would be recoverable with a further regrind. However, the encapsulated grains are smaller than 12 μm in diameter, hence an extremely fine regrind (~80 % -10 μm) would be required to liberate them. On the other hand, it is possible that a somewhat coarser regrind would fracture the encapsulating particles and expose the enclosed grains. A series of grinding and cyanidation tests would likely determine whether regrinding would increase recoveries sufficiently to warrant the additional cost. The problem is complicated because some of the gold occurs as aurostibite which is not cyanidable. The proportion of gold occurring as aurostibite cannot be determined from the observed small population of grains. On the other hand, the Au assays for 106 to 44 μm float subfractions are nearly as high as the Au assays for the total sample. It is interpreted that the gold in these sub-fractions occurs as very minute inclusions of Au-Hg-Ag alloys within silicates, and that most of the gold in the samples occurs in this form.

The higher Au content in the -44 μm fractions than in the +44 μm fractions suggests a higher liberation of Au minerals, either aurostibite or liberated (uncyanided) Au-Hg-Ag and Au-Ag alloys, in the fine fractions. The liberated Au-Hg-Ag and Au-Ag alloys would be recoverable after regrinding. On the other hand if the main Au mineral in the -44 μm fraction is liberated aurostibite, the amount of gold recoverable by regrinding would be very small because the -44 μm fraction represents nearly 60 % of the material.

RECOMMENDATIONS

1. Conduct a series of grinding and cyanidation tests on the samples to determine whether enough gold would be recovered to warrant regrinding the tails.
2. Perform a mineral balance to determine the proportion of gold occurring as (a) encapsulated gold plus liberated "uncyanidable" gold, (b) "invisible gold" in pyrite and arsenopyrite, and (c) gold in aurostibite.

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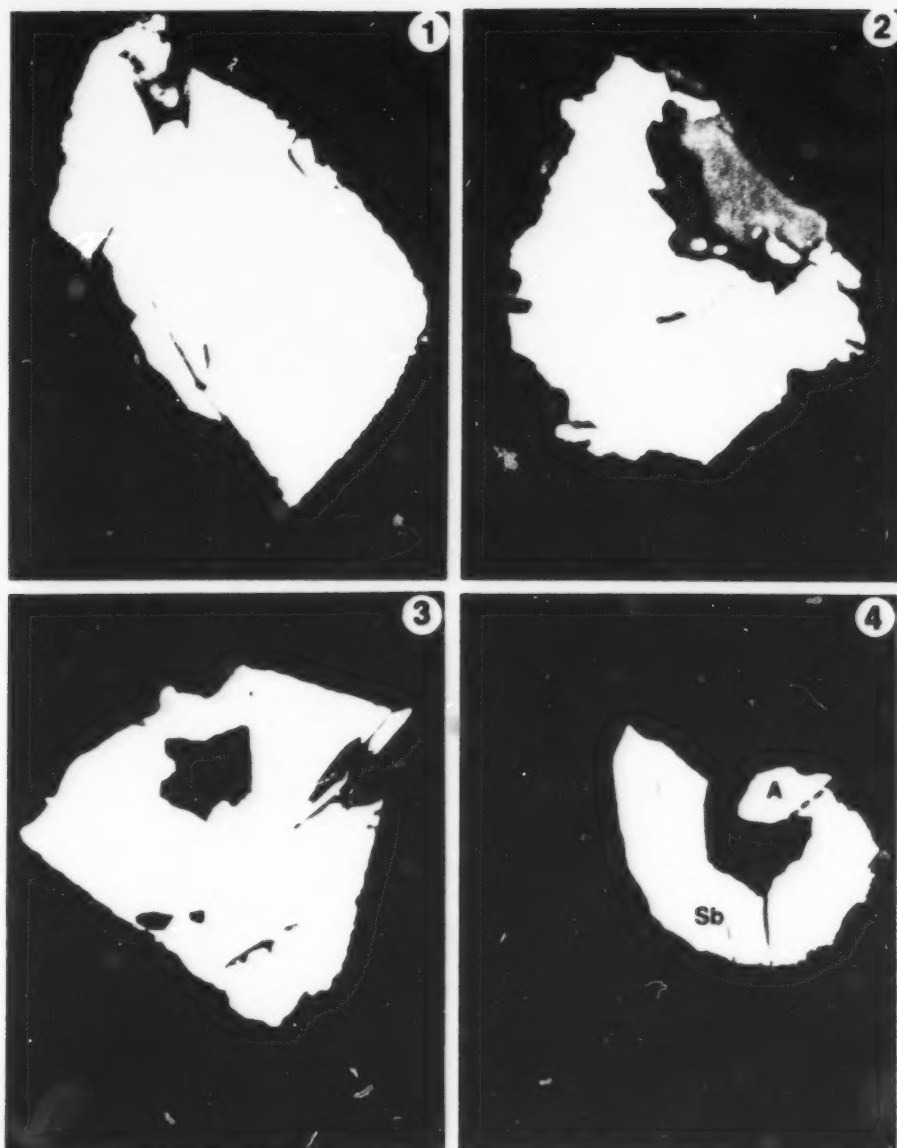


Figure 1. Liberated grain of aurostibite. Sink product 106 to 44 μm , sample No. 1.

Figure 2. Aurostibite (white) associated with berthierite (darker grey) and stibnite (light grey). Sink product 106 to 44 μm , sample No. 1.

Figure 3. Aurostibite with minor quartz (dark grey). Sink product 106 to 44, sample No. 1.

Figure 4. Aurostibite (A) with native Sb enclosed in quartz (Qtz). Sink product 106 to 44, sample No. 1.

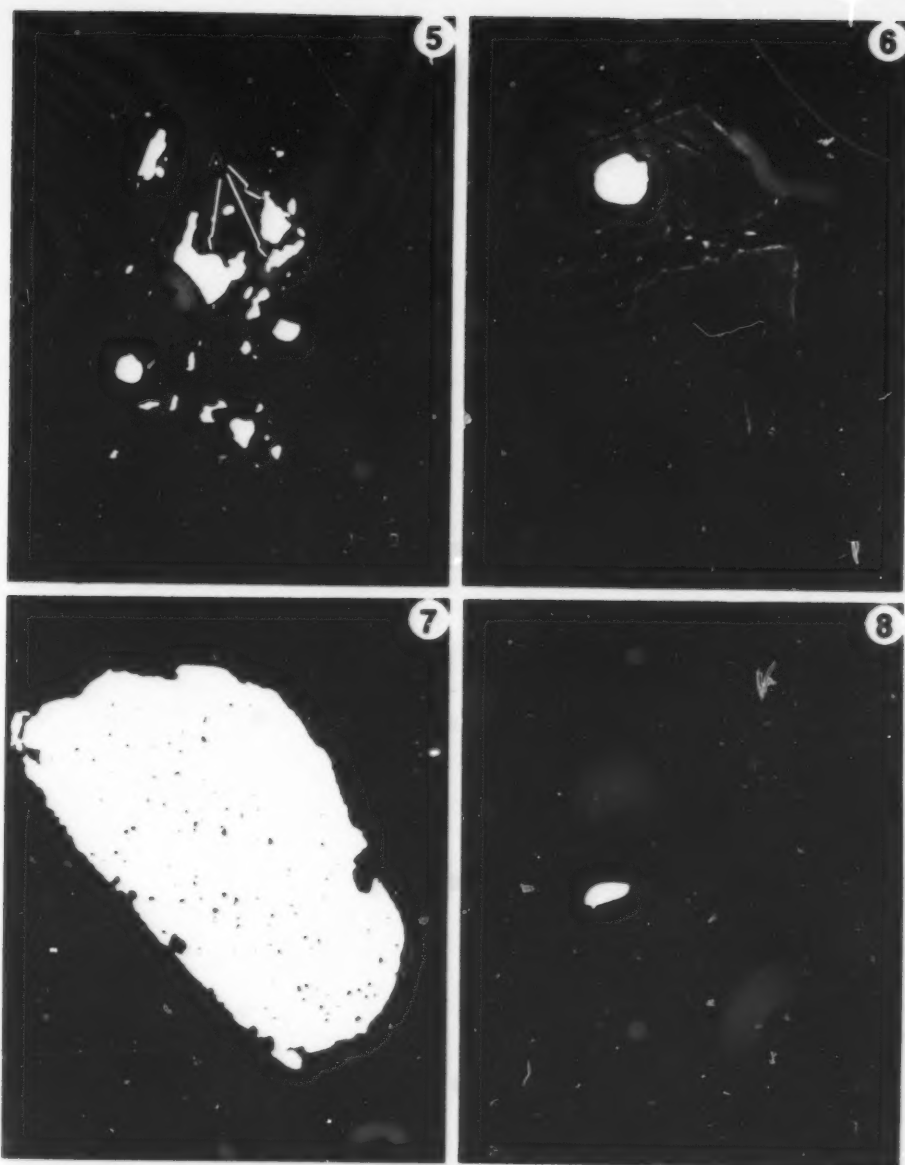


Figure 5. Disseminated aurostibite (A, arrows) and native Au-Hg-Ag alloy in Ca-Al and Na-Ca-Al silicates. Sink product 106 to 44, sample No. 1.

Figure 6. Au-Hg-Ag alloy grain (white) enclosed in pyrite. Sink product 106 to 44 μm , sample No. 1.

Figure 7. Liberated Au-Ag alloy grain. Sink product 106 to 44 μm , sample No. 2.

Figure 8. Anhedral Au-Hg-Ag alloy inclusion (white) in pyrite. Sink product 106 to 44, sample No. 2.



Figure 9. Anhedral Au-Hg-Ag alloy grain (Au) in titanite, with minor pyrite (Py). Sink product 106 to 44 μm , sample No. 2.

Figure 10. Small Au-Hg-Ag alloy grains enclosed in quartz. Sink product 106 to 44 μm , sample No. 2.